SYSTEM AND METHOD FOR ADAPTIVE RESOURCE MANAGEMENT

Thomas C. Harrop
924 Palmer Circle
Folsom, CA 95630

Citizenship: U.S.

RELATED APPLICATIONS

This application is related to co-pending application entitled "SYSTEM AND METHOD FOR POLICY-BASED NETWORK MANAGEMENT," assigned serial number 09/469,025, filed December 21, 1999; co-pending application entitled "SYSTEM AND METHOD FOR A COMMON OBJECT CLASS LIBRARY," assigned serial number 09/469,026, filed December 21, 1999; co-pending application entitled "FAULT MANAGEMENT SYSTEM AND METHOD," assigned serial number 09/345,634, filed June 30, 1999; and co-pending application entitled "METHOD AND SYSTEM FOR PREDICTIVE RESOURCE MANAGEMENT," assigned serial number [Attorney Docket No. 50671-P012US-10004457], filed October 30, 2000, all of which are assigned to a common assignee, the disclosures of which are hereby incorporated herein by reference.

TECHNICAL FIELD

This invention relates to a system and method for adaptive resource management and more particularly to such systems and methods which allow for the monitoring of selected resources and for comparing the monitored resource against known and/or anticipated current/future usage criteria.

BACKGROUND

Typically, a company has a computer system with a certain amount of resources allocated for use by the system. Those resources could, for example, be e-commerce such as Internet, wireless, and the like. As time passes, applications are added to the system and eventually the system requires additional resources. When this happens, a user must manually add more resources to the system.

In this context, resources could be memory, CPUs, disk storage, network capacity, in fact, anything that makes the system more reliable or more robust. Thus, as time passes, the memory is required to hold more and more data, or the CPU must go faster, or a link for a network (such as the Internet) must be larger in capacity or faster in speed.

Currently, in order to add resources, a user must identify the problem and then identify the required resource(s). Then the user would have to turn the machine off, insert more resources into the system and restart the machine. This, of course, requires a certain amount of down time, a high technical skill level and the actual resource(s).

The problem is that most users do not understand when a new resource is necessary, so the upgrade is made only when it becomes an issue and only when it is determined that the problem will be solved by adding more resources to the system. The problem is even more difficult when the trouble comes from a resource that is only needed once in awhile, such as once a day, once a month, or once a year. When the resource is added it then is always available even if the demand time has passed (i.e., a demand for such resource no longer exists) or the demand for such resource is sporadic. For resources that are costly, this is a problem.

SUMMARY OF THE INVENTION

The present invention is directed to a system and method which is designed to monitor selected active resources on the system, including the CPU, memory, networking, and/or the input/output ("IO") resources of the system. The system also monitors the processes (applications) that are running on the system to see what the utilization of the resources are at any given time so as to anticipate future use levels. This can be done, if desired, on a user by user basis.

The system then stores the monitored data so that it can generate statistics which are gathered, as examples, every minute, every day, or every week or as otherwise desired. Thus, the system and the users can know what has happened for any period desired. The system is designed to use the gathered data to determine (or predict) what resources are (or will be) necessary and allow additional resources to be added by that application when needed. If the resource is no longer required, it can then return it to a pool of resources. The resource pool can be global (i.e. shared over the Internet), or can be enterprise wide which effectively allows for segmenting the system when needed.

Using this system and method, a user need not over plan (buy more resources than are needed up front), thereby conquering resources. The system and method operates, if desired, without user intervention and uses the monitored data to anticipate a problem, thereby eliminating unforseen problems. The proactive nature of the system reduces the amount of down time, which increases system reliability over time as opposed to spikes and periods where it is going to be down.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that

such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention.

BRIEF DESCRIPTION OF THE DRAWING

For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

FIGURE 1 shows a preferred embodiment of a central management station operating in conjunction with a number of network elements;

FIGURE 2 shows a prior art central management system;

FIGURE 3 shows a preferred embodiment of a process using the principle of this invention;

FIGURE 4 shows an example of a process for utilizing the gathered information to change the resource level; and

FIGURE 5 shows an example of one statistical analysis for one embodiment of the invention.

DETAILED DESCRIPTION

FIGURE 1 shows central management station11, including software package 101, which talks to generic gateways (GW) 12-1, 12-2, ...12-N, (referred to collectively as gateway(s) 12) which, in turn, communicate with network elements (NE) 13-1, 13-N, one or all of which may be, for example, a Sun system Model E10000, which can be fully populated with resources. The NE could be a fixed system, such as NE 13-4 with a fixed amount of resources or a system that allows for the permanent, or temporary, addition of resources via the Internet such as NE 13-1. Different NE's can be arranged in different formats, as desired.

Central management station 11 determines, via software program (SW) 101, what particular interval is desired and what parameters and elements are to be maintained, and instructs polling gateway(s) 12 (e.g. polling gateway 12-1) to poll specific networks elements. These network elements can be fixed system elements (such as NE 13-4) or an element (such as NE 13-1) with potentially unlimited resources. The polled elements would communicate back to the gateway the information that is requested.

Memory disk space, CPU, system IO, network bandwidth utilization, number of processes, and number of users are all examples of information that can be communicated back to gateway(s) 12. Gateway(s) 12 receives the information as requested from a particular network element and process the specific pieces of information that are required. As an example using memory utilization, the system could return average storage bits numbers, low balances, as well as swapping information. Not all of the information available from the CPU is necessary or desired so only the specific requested numerical information is obtained. Once that information is parsed out, it is sent to central management station 101 which performs a statistical analysis (as will be discussed), or any other desired type of analysis, on the returned information. The analysis, as well as the raw data, if desired, is stored. Based on that information, an analysis is performed which predicts a time to fail based on resource utilization, and, if desired, allocates additional memory, if such is available. For example, assuming more memory is required and using resource NE 13-1, the system is requested to allocate an additional Mbyte of memory. When the memory has been added, the proper

charge is made to the user for the memory. Under some situations the system might only require the memory for a certain period of time and this would be factored into the cost. Also, the system could decide that less memory (or other resource) is needed and "give back" some resources. In this manner, such unneeded resource may be returned to the overall "pool" of resources.

Perhaps memory overload was temporary and is determined to exist for 72 hours with the system returning to "normal" thereafter. Under this situation, the system could go onto the Internet (or otherwise access a remote enterprise facility) and negotiate for storage capacity of a certain number N Mbytes for 72 hours.

In the case of a fixed system, the system would alert the user when it is determined that it is going to run out of resources. The system could prompt the user to take some specific action, and it can predict that if that action is not taken by a particular time or date, a certain list of "bad" things will happen. Thus, the system not only notifies the user that it is running out of resources or that the system is already out of resources, but it predicts that the system is on course to run out of resources at a particular time in the future.

The system can be set so that any addition of resources is controlled by the user or the resource addition can be automatically accomplished. In the situation where resources are automatically added (or subtracted/released), central management station 11 instructs gateway 12-1, for example, to communicate to network element device 13-1 and issue the specific commands to allocate the resource(s) necessary. Gateway 12-1 may be instructed in a similar manner to communicate to network element device 13-2 and issue the specific commands to allocate the resource(s) necessary.

FIGURE 2 shows a prior art central management station 21 in communication with network elements 22-1, 22-2, ... to 22-N. As shown, distributed gateways are not utilized for processing, e.g., for instructing the network elements to allocate necessary resources(s). In such systems, gateways may be implemented for performing some type of processing, but such prior art systems do not include gateways capable of managing the network elements by instructing such elements to add more resources when needed.

As shown in FIGURE 2, central management station 21 (for example, IBM and Tivoli units) could monitor the network elements but are not proactive. These prior art systems could only report on the current utilization of each element and do not give an estimate as to when those elements would run out of particular resources. Such systems cannot allocate additional resources even if such additional resources were available to those particular elements. Thus, the network administrator would have to continuously monitor the system and on his/her own calculate the various resource allocation and then decide what is the appropriate action to take (e.g., when to allocate additional resources, and how much additional resources to allocate). This is management by reaction and usually results in down time. In some cases the operator is proactive in actually making sure he/she is aware of the system by knowing what is happening and determining when to add or remove resources. However, such reliance on the operator manually taking such action is undesirable.

Turning now to FIGURE 3, an exemplary flow diagram of an operational process 30 that may be implemented according to a preferred embodiment of the present invention is shown. As shown, process 30 starts in operational block 301 with a management system which sends a request in block 302 to a gateway. The gateway receives the request at block 303 and, in turn, requests information from a network element at block 304. There is a bidirectional communication between the gateway and the selected network element, wherein the network element responds to the gateway at block 306. The gateway then parses out the relevant information to the relevant resource, as shown in operational block 307. For example, again assume that a memory unit is being evaluated. The information pertaining to the memory is sent back through the gateway to management station 11 (FIGURE 1) via operational block 308. The management system then processes the relevant information, storing some of that information in the run-time management information data base 15 (FIGURE 1). As shown in FIGURE 4 and based on the information that has been obtained by process 400, management station 11 may either display a warning to the user, or may autonomously attempt to allocate additional resources, block 404, to the actual network element via block of 309 of FIGURE. 3. As shown in FIGURE 4, when central management

station 11 ("CMS") receives the information, operational block 401, it will do one or more of preestablished analyses, block 402, which could include, for example, a statistical analysis, a count, a comparison of needed memory (or other resource) to available memory (or other resource), processing speed, delay times, latencies, etc. That type of statistical analysis may be user defined. For example, a user interface (e.g., a graphical user interface) may be presented by the CMS to a user to enable the user to define (e.g., by using rules, which may include logical operands) the type(s) of statistical analysis to be performed. In the present example, the statistical analysis will take a moving average of the particular item that is being monitored from the network element and stores the results, as shown in block 403.

For instance, in a preferred embodiment, the system network administrator has an interface to the CMS, preferably visually using a GUI, which allows the network administrator to select or define statistical equations or whatever parameters are desired to be monitored. The administrator can choose from moving average, regression methods or whatever different types of specific method he/she wants to choose from, depending upon the resource(s) being monitored and depending upon the desired result. Additionally, these analyses can be changed under automatic control or can be changed based on system triggers (e.g., based on certain triggering events occurring), for example.

When the analysis is complete, as shown in block 404, the results will be stored in data base 15 (FIGURE 1). After the information is stored, the system determines if a critical threshold has been reached. If the threshold has been reached in a fixed system, an alert to the operator will be generated stating that limits for specified resources are about to be reached. Preferably, the system can specify how much time remains until failures will be encountered. In a non-fixed system, the system preferably attempts to allocate additional resources to allow the processes to continue without intervention. Most preferably, the system autonomously determines whether resources are available that can be allocated and at what cost and, if desired, the user is notified. Of course, any level of user interaction desired may be implemented, from obtaining prior approval from a user for a resource allocation to simply notifying the user once a resource allocation has been completed.

FIGURE 5 shows one example of a specific user-defined statistical analysis 501 that could be implemented for a moving average, as discussed above. The gathered data would be calculated and the result would be stored as, in this example, ΔT. The user would define threshold for ΔT that would cause a trigger as an indication that a threshold had been reached. This can be done in any of a number of ways, for example, by well-known comparison techniques against values stored in memory.

Thus, a user could set several limits, such that for example, when ΔT reaches 80 then the system takes a certain action, and if ΔT reaches 90, the system takes a certain other action. In a most preferred embodiment, a user may define both the triggers and the actions to be taken by the system upon the occurrence of each trigger. Of course, different limits and different rules (using a rules-based engine if desired) could be set for particular network elements that are being monitored. Thus, for example, one network element may be managed in one fashion, while another network element may be managed differently (e.g., according to different user-defined rules for resource allocation).

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.